Gyrokinetic modelling of baseline H-mode JET plasmas with C Wall and ITER-like wall

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*See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia

Introduction

- Materials of plasma facing components at JET changed from carbon to metallic — beryllium and tungsten[1].
  - So-called ITER-like wall, similar to wall envisioned at ITER.
- Differences in plasma operations such as higher gas puffing rate to mitigate W accumulation in ILW discharges affect global confinement[2] — worse for baseline H-mode ILW discharges[3].
- Deterioration due to lower edge (pedestal) temperatures.
- This also changes NBI heat deposition so changed core energy confinement also observed with smaller τ_E^e, similar τ_E^i.
- Need to understand differences in core confinement.

Discharge parameters

- Database of matched CW-ILW discharges created at JET.
  - Similar plasma current, toroidal magnetic field, applied NBI power, average electron density, safety factor, and triangularity.
  - Input profiles taken from TRANSP[4,5] runs and smoothed in time (1 s) and space.
  - Geometry parameters extracted from EFIT[6] reconstructions.

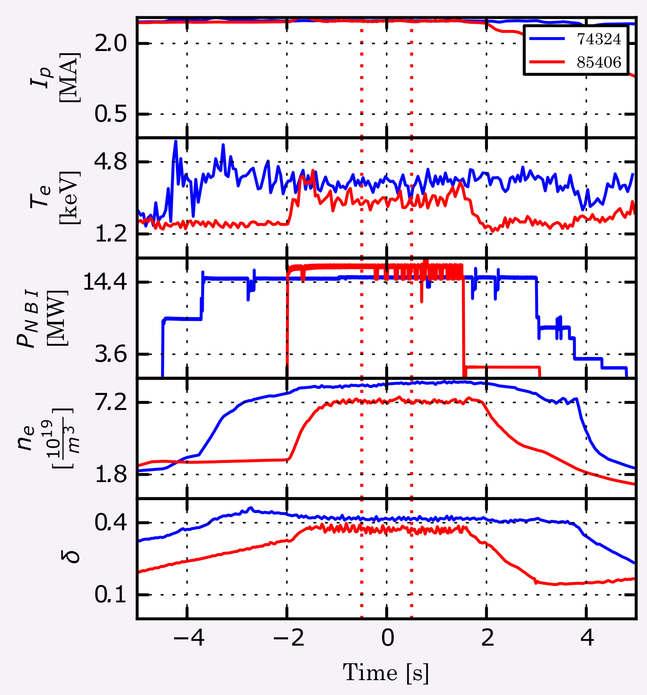


Figure 1: Time evolution of two matched discharges

Shot	$\hat{s}$	q	δ	T_i/T_e	T_e	n_e	R/L_{T_i}	R/L_{T_e}	$B\,(\mathrm{T})$	$\beta\,(\%)$	$\nu_e\,(10^{-3})$	Z_{eff}	$\gamma_{\mathrm{E\times B}}$	Ω_{tor}
74313	0.56	1.42	0.097	0.92	2.31	9.04	6.56	6.19	2.62	1.2	1.8	1.58	0.056	32
85407	0.66	1.32	0.081	1.00	1.70	8.19	5.96	8.28	2.68	0.78	3.0	1.05	0.10	26
74324	0.55	1.44	0.097	0.89	2.35	8.72	4.92	5.96	2.64	1.19	1.7	1.56	0.040	31
85406	0.64	1.34	0.083	0.98	1.78	7.56	6.78	8.38	2.68	0.75	2.5	1.05	0.22	31

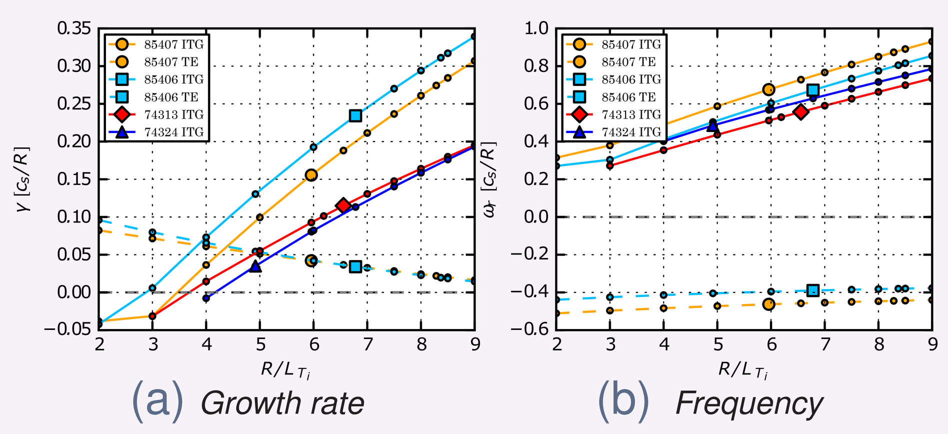
Table 1: Discharge dimensionless parameters at $\rho = 0.5$. Collision frequency calculated as $\nu_e = \pi \ln \Lambda e^4 n_e R/(2^{3/2} T_e^2)$. Ω_{tor} in $\mathrm{krads^{-1}}$, T_e in keV, n_e in $10^{19}/\mathrm{m}^3$

GENE simulations setup

- ITG/TE mode turbulence studied in two pairs of discharges using GENE[7] at mid radius.
- Simulations include finite β-effects, collisions, impurities, realistic (Miller) geometry, gyrokinetic treatment of all species.

Linear R/L_{T_i} scan

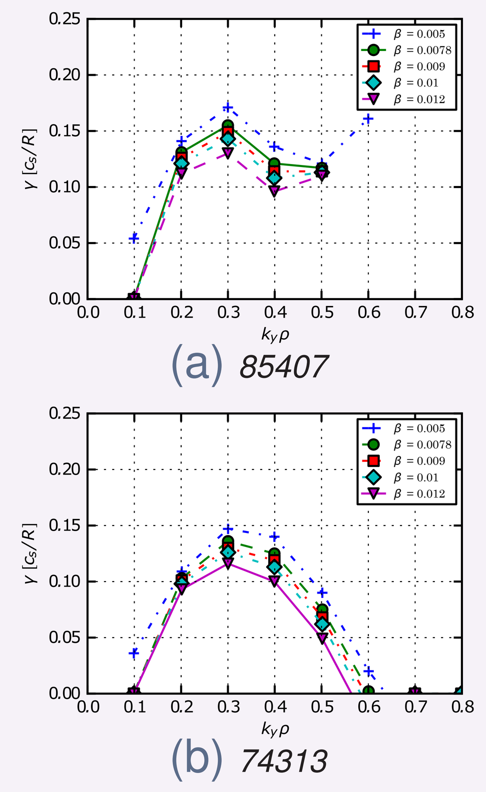
- All four discharges ITG dominated.
- Scaling in ion temperature gradient performed because of measurement uncertainties.
  - ILW discharges more unstable at same R/L_{T_i} with slightly lower ITG threshold.



(a) *Growth rate* (b) *Frequency*

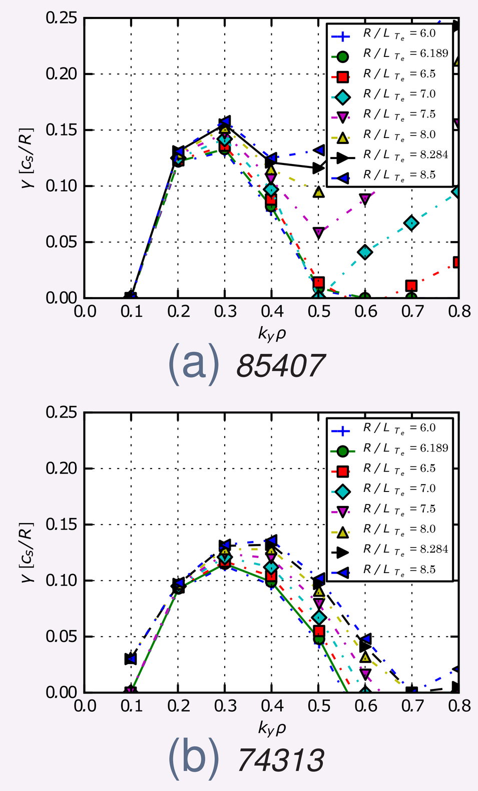
Figure 2: Linear R/L_{T_i} scans for the four discharges at $k_y\rho_s = 0.3$.

Linear sensitivity scans



(a) *85407* (b) *74313*

Figure 3: Scaling of eigenvalue spectra with β



(a) *85407* (b) *74313*

Figure 4: Scaling of eigenvalue spectra with R/L_{T_e}

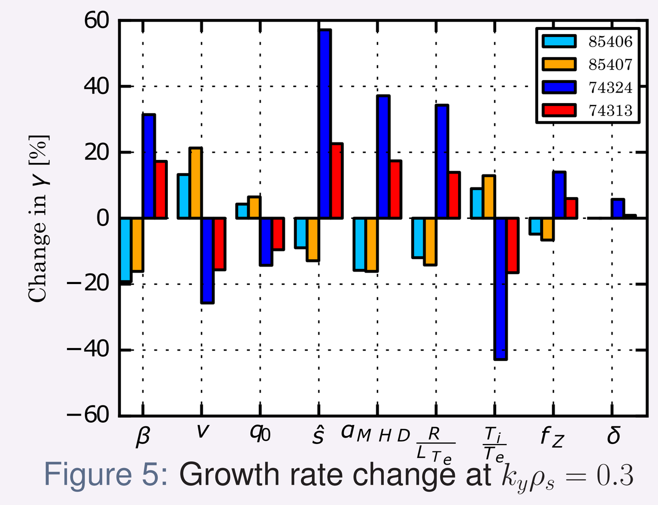


Figure 5: Growth rate change at $k_y\rho_s = 0.3$

- Linear sensitivity scans performed, investigating relative change in growthrate for a number of parameters.
  - Relative change in plasma β, α_{MHD}, R/L_{T_e} and $\hat{s}$ serve to destabilize the ILW discharges.
  - Change in collisionality and T_i/T_e stabilize ILW discharges.

Nonlinear results

- Stiffness of ILW discharges larger than CW discharges.
- Follow linear trends, larger fluxes for the ILW discharges.
  - Core τ_E^i similar while τ_E^e shorter for ILW discharges.
  - Experimental heat fluxes lower at high R/L_{T_i}, more realistic results with rotational effects.

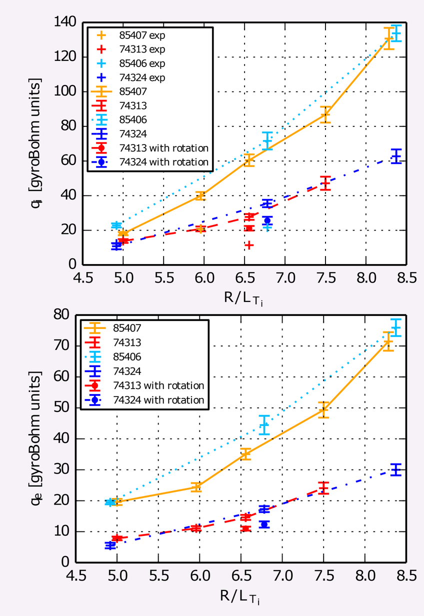


Figure 6: Heat fluxes, normalized units

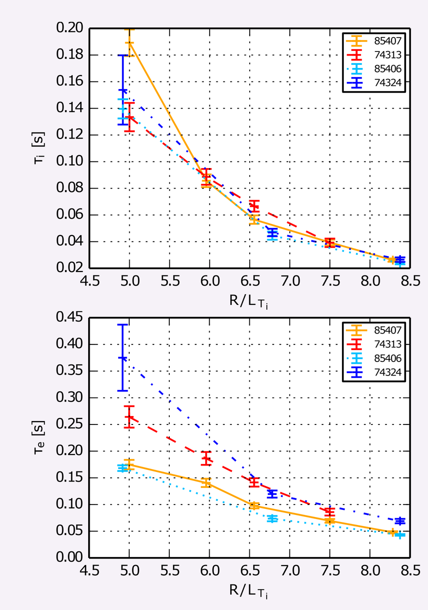


Figure 7: Energy confinement times

Conclusions

- Core confinement affected by changes in key plasma parameters due to degradation of edge pedestal.
  - Expect core confinement to improve if pedestal recovered.

Acknowledgements and references

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